

Diseases of Ginger (*Zingiber officinale*) in Hawaii



E. E. Trujillo

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WARNING

The chemicals listed for control of ginger diseases should be considered dangerous. The manufacturers' recommendations for application and handling should be strictly adhered to. The United States Department of Health, Education, and Welfare, under the provisions of the Pesticide Chemicals Amendment to the Federal Food, Drug, and Cosmetic Act, has established criteria to govern the use of each chemical to which clearance for use has been given. Before using any pesticide, growers should always check its current status with their county agent or the local representative of the U.S.H.E.W., Food and Drug Administration.

PHOTOGRAPHS ON COVER: LEFT: *Top*, ginger rhizomes affected by *Fusarium* yellows; *bottom*, healthy rhizomes. RIGHT: *Foreground*, ginger plants affected by *Fusarium* yellows; *background*, healthy plants.

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THE AUTHOR

DR. E. E. TRUJILLO is Assistant Plant Pathologist at the Hawaii Agricultural Experiment Station and Assistant Professor of Plant Pathology, University of Hawaii.

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INTRODUCTION

In Hawaii, ginger is a specialty crop that produces excellent cash returns in spite of serious losses due to disease and insect problems. It is estimated that a threefold increase in production is possible with effective disease control. A reduction of production costs by eliminating diseases would make Hawaiian ginger more competitive in the market. Important also is the fact that disease-free rhizomes can be stored for longer

periods, and thus can be marketed during periods when market prices are higher.

The purpose of this circular is to describe the common diseases of ginger and to discuss their possible controls. In the preparation of this circular, all the available pertinent information and publications of this and other experiment stations have been consulted. Acknowledgment is made of the use of such information.

THE CROP

Ginger (*Zingiber officinale* Roscoe) is a fibrous-rooted perennial plant with branched underground stems called rhizomes. The above-ground portion of the plant consists of several aerial shoots which are about 3 feet tall. The plant is indigenous to the tropics and susceptible to frost injury. In Hawaii the temperatures are cool enough during December and January to induce both rhizome dormancy and death of the foliage. Therefore, the crop is planted in late winter or early spring and harvested in the winter months. Because ginger does not produce

true seeds, portions of the underground rhizome weighing from 1 to 4 ounces known as "seed-pieces" are used for planting material. The cost of planting material is high and growers usually save some of the best portions of a crop for "seed."

Continuous recropping of the same land is common in Hawaii. This, combined with the use of planting material saved from the previous year, has contributed to the build-up of a number of disease-producing organisms which have become destructive in many areas.

THE DISEASES

Plant diseases are of two general types, parasitic and nonparasitic. The parasitic diseases are caused by living organisms which subsist in whole or in part on the plant, thereby making the natural development of the plant impossible. These diseases are caused by fungi, bacteria, viruses, and nematodes. Nonparasitic diseases are caused by unfavorable environmental conditions such as drought, temperatures unfavorable for plant growth, and nutrient deficiencies or excesses in the soil.

Figure 1. Bacterial wilt of ginger showing foliar symptoms. Rapid wilting of the green foliage prior to yellowing is characteristic. Two or 3 days later the leaves turn yellow-brown and dry.



Parasitic Diseases

Bacterial Wilt

Bacterial wilt of ginger is a very destructive, parasitic disease and has been reported from most areas of Hawaii where ginger is grown commercially.

The first symptoms of wilt are a slight yellowing and wilting of the lower leaves. The wilt progresses upward, affecting the younger leaves, followed by a complete yellowing and browning of the entire shoot. Under conditions favorable for disease development, the entire shoot becomes flaccid and wilts with little or no visible yellowing. However, the plant dries very rapidly and the foliage becomes yellow-brown in 3 to 4 days (fig. 1). Young succulent shoots frequently become soft and completely rotted and these diseased shoots break off easily from the underground rhizome at the soil line. The underground parts are also completely infected. Grayish-brown discoloration of the rhizomes may be localized if the disease is at an early stage of infection, or discoloration may be general if the disease is in an advanced stage. A water-soaked appearance of the central part of the rhizome is common. In advanced infections, the entire rhizome becomes soft and rots. Bacterial wilt of ginger can be distinguished from other rhizome rots of ginger by the condition of the rhizome and the foliage. A better diagnostic feature is the extensive bacterial ooze that shows as slimy, creamy exudate on the surface of a cut made in the rhizome or on the above-ground stem of an infected plant (fig. 2).

The bacterial wilt of ginger is caused by a strain of *Pseudomonas solanacearum*. The strain of the bacteria attacking ginger will weakly attack tomato, pepper, and



Figure 2. Cross sections of bacterial wilt-diseased rhizome (left) and pseudostem (right) showing extensive bacterial ooze. (Photo courtesy of M. Ishii.)

eggplant (3, 5). Although laboratory tests have shown that the strain that causes severe tomato wilt does not attack ginger, a relationship between the strains of the bacteria does exist. Although relationships may be of little importance to the grower, there is a possibility that under field conditions, the tomato strain could be severe on ginger and the ginger strain severe on crops belonging to the tomato family. Thus, it is highly undesirable to plant either crop in a field in which the other had been diseased.

The bacterium that causes this disease is soil-borne and also may be carried in infected rhizomes. There is also a possibility that some of the insects that feed on the diseased ginger foliage or rhizome could be vectors of the bacteria if they later feed on healthy plants. Commonly, bacterial wilt can be spread from diseased to healthy rhizomes with the knife used to cut the rhizomes into seed-pieces.

New soil can be contaminated with the bacteria by use of contaminated farm equipment or by irrigation water flowing through infested soil.

Fusarium Yellows and Rhizome Rot

Fusarium yellows is probably the most serious problem of ginger because it has become more widely spread than bacterial wilt. It has been found in most commercial plantings in the State of Hawaii. Plants infected by the fungus, *Fusarium oxysporum* f. *zingiberi*, do not wilt rapidly as in bacterial wilt (6). Instead, infected ginger plants are stunted and yellowed. The lower leaves dry out over an extended period of time (fig. 3).

It is common to find yellow, stunted above-ground shoots among apparently healthy green shoots. The plant finally dries out as the fungus invades the entire vascular system of the underground rhizomes.

The rhizomes show a creamy brown discoloration of the water-conducting portion of the rhizome and a prominent black dry rot of the tissues of the cortex (the portion outside of water-conducting tissues) (fig. 4). The rhizomes do not become soft and water-soaked as in bacterial wilt, and when cut they do not ooze bacterial slime (fig. 5).

The disease may start in the seed-piece originally planted; also, it has been observed that the fungus can readily invade wounded healthy seed planted in infested soil. As the rot advances into newer rhizome sections, the cortex shows sunken areas. This is especially noticeable on infected rhizomes in storage.

Figure 3. *Fusarium* yellows symptoms in the field characterized by slow wilting of older shoots. Plants are stunted and yellow. The lower leaves dry out over an extended period of time.



Fusarium oxysporum f. *zingiberi* is a fungus that can be carried in infected rhizomes. The fungus also produces resting structures (chlamydospores) in the decomposing tissues of infected rhizomes. Therefore, tissues from infected crops remaining in the field serve as a reservoir of the fungus. Once a ginger field becomes infected, the fungus can remain in the soil for many years. Ginger harvested from fields contaminated with the *Fusarium* yellows fungus may be infected and the fungus will continue to destroy the rhizome tissues in storage. This is a dry rot characterized by collapse of the cortical tissues, occasionally accompanied by a purpling of the infected areas of the rhizome, and a white cottony mycelial growth on the cut surfaces of ginger pieces.

Root-knot Nematode

Ginger rhizomes can be severely infected with *Meloidogyne incognita*, the root-knot nematode. The nematode affects the market quality of the crop very seriously but normally does not destroy the rhizomes. This parasite does not form prominent surface galls in ginger rhizomes as it does in other plants, and in ginger the external symptoms are usually masked. In severe infections the cortex of the rhizomes appears somewhat lumpy and cracked. Apparently when the female nematode reaches maturity, the surface galls break the epidermis of the rhizome and the rhizome surface becomes corky in appearance. When the cork layer is peeled off, small, circular, water-soaked, slightly brown lesions are observed (fig. 6). Mature females of the nematode are found in these lesions. These water-soaked areas below the epidermis of the rhizomes are quite numerous in severely infected rhizomes. The nematode lesions can serve as points of entry to common bacteria and fungi



Figure 4. Healthy rhizomes (*right*); *Fusarium* yellows-diseased rhizomes (*left*) showing prominent black dry cortical rot.



Figure 5. Cross sections of healthy rhizomes (*top*) and *Fusarium* yellows-diseased rhizomes (*bottom*) showing creamy brown discoloration of the vascular cylinder. The second cross section from the left shows discoloration extending to the cortex of the rhizome. Notice absence of bacterial ooze.

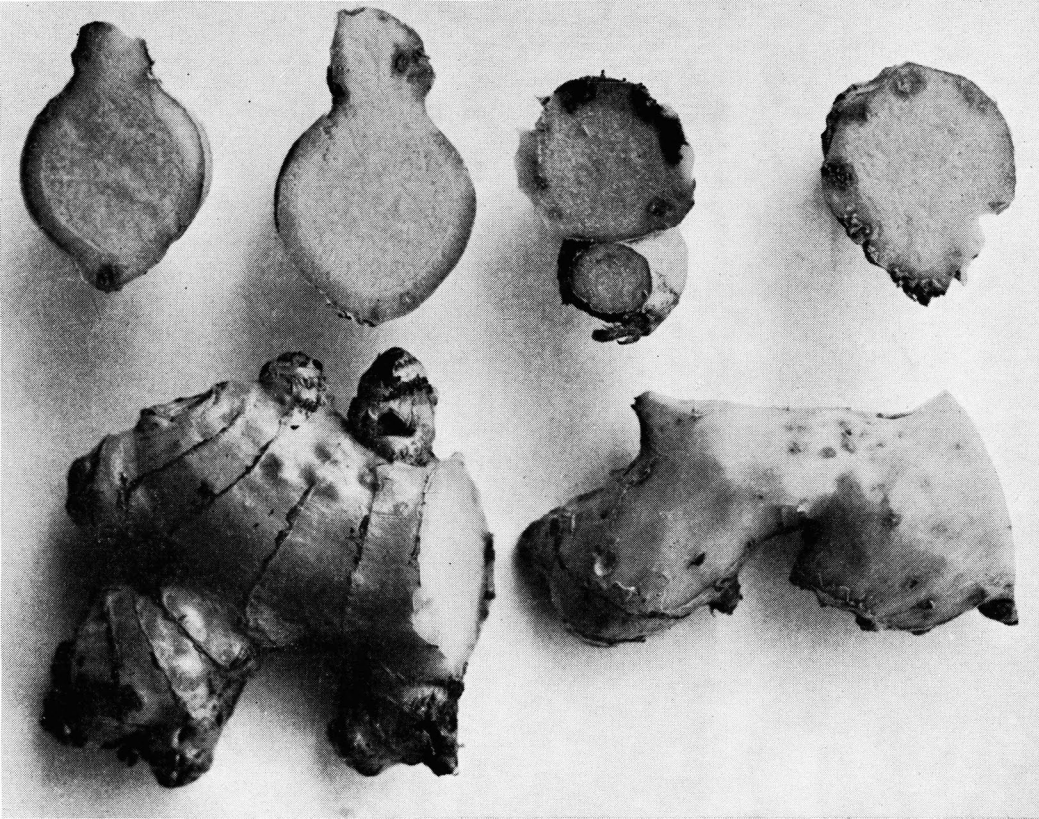


Figure 6. Ginger rhizomes infected with the root-knot nematode, *Meloidogyne incognita*, showing water-soaked, circular lesions on the cortex just below the cork layer. Notice lumpy surface galls on the cortex of the severely infected rhizome at lower left.

which are otherwise unable to invade uninjured tissues, and the rhizomes may be destroyed in storage by such organisms. Nematodes such as *Meloidogyne* sp. are known to invade immature tissues only. It is not known how infection of the ginger rhizome takes place.

Pythium Soft Rot

Pythium graminicolum has been reported as a cause of severe soft rot of ginger in the field (4). The fungus has been reported to be carried in seed-pieces. On Kauai this fungus has been isolated from ginger rhizomes showing soft rot (7). Although this problem was not considered very serious, it is possible that under high rainfall and poorly drained soil, *Pythium* soft rot of ginger could be

a problem in Hawaii. The yellowing shown by the affected plants can be confused with symptoms of *Fusarium* yellows and with other problems such as mineral deficiencies. The soft rot caused by *Pythium* does not produce offensive odors, which are characteristic of bacterial rots.

Bacterial Soft Rot

Bacteria of the *Erwinia* group are sometimes found associated with a type of soft rot of ginger encountered in water-logged fields. The softening of the tissues is accompanied by the production of a strong odor. The disease is more prevalent in rhizomes that have formed deep in the ground. The sections closer to the surface are generally healthy. This problem is not found in well-drained soils.

Nonparasitic Diseases

Sunburn

Young ginger plants are very susceptible to sunburn when screen temperatures exceed 90°F. (Sunburn is not due to high temperatures but to high light intensity.) Mild sunburn affects only the leaves, but

acute sunburn damages the entire shoot (2). This problem is seldom encountered in Hawaii. Drought and lack of water may cause the same effects as sunburn.

Lime-induced Chlorosis

Excessive liming or abundant coral sand in the soil may cause yellowing of the blades and poor growth.

CONTROL (MAIN DISEASES)

When the life history of a disease-producing organism is known, it is usually possible to destroy it or to prevent its spread. The most serious diseases of ginger are seed- or soil-borne. The seed phase of the diseases may be controlled by seed selection and by application of the seed treatments described below. The most effective means of eradicating these pathogens from the seed is by a process of seed certification involving "subculture" of apical shoots in sterile nutrient agar media and propagating such material in disease-free soil. However, this method of seed certification is a costly operation that cannot be handled by small growers.

The soil-borne phase of these diseases may be controlled by soil sterilization or soil disinfection.

Seed Selection

Because certified or inspected seed is not available to protect the grower from bacterial wilt, *Fusarium* yellows, root-knot nematodes, and possibly *Pythium* soft rot, the grower must be careful about the source of seed he plants. He must be familiar with the symptoms of each major disease and avoid saving seed from diseased plants.

After a careful selection of apparently healthy seeds, a hot-water treatment

may be applied to eliminate root-knot nematodes (fig. 7). The temperature must be carefully controlled and the ginger should be completely dormant, otherwise germination of the seed will be reduced. The temperature should be kept at a constant 122°F. Treatment for 10 minutes at this temperature eliminates the nematodes from the tissues (6). The hot-water treatment is ineffective against *P. solanacearum*, the bacterial wilt organism, and *F. oxysporum* f. *zingiberi*, the *Fusarium* yellows organism, when these pathogens are inside the vascular tissues of the seed-pieces. The seed can be surface-disinfected after cutting by dipping the ginger in a 10% Clorox solution for 10 minutes (use 1 part of commercial Clorox to 9 parts of water). Other materials such as panogen, PMA (phenyl mercuric acetate), etc., could be used if the seed pieces are discarded at harvest time; these materials have not been cleared by the United States Food and Drug Administration.

Soil Fumigation

Fusarium yellows of ginger in the soil can be effectively controlled with a methyl bromide-chloropicrin 2:1 mixture at 450 to 600 pounds per acre under polyethylene tarping (7). This mixture, with trade

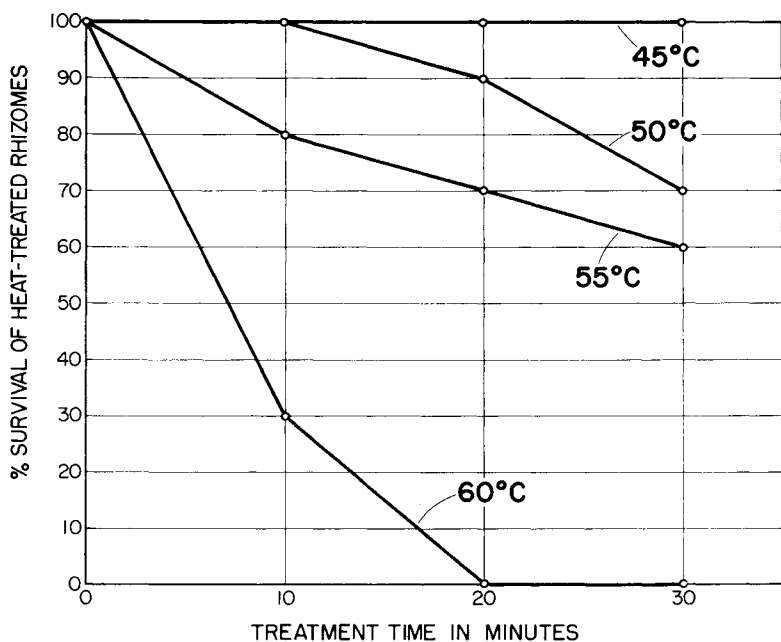


Figure 7. Curves showing the effect of heat treatment at 5 different temperatures on the survival of dormant ginger rhizomes. None of the temperatures at which the ginger survived killed the *Fusarium* yellows pathogen. The root-knot nematodes can be controlled at treatment temperatures of 50°C (122°F) or above for 10 minutes.

names such as Dowfume MC-33, Pathofume, etc., is also good as a nematocide, an herbicide, or a bactericide. Preliminary field experiments in an area heavily infested with *Fusarium* yellows have shown that if the fumigant is placed at a 9-inch depth, the disease could be effectively controlled provided disease-free ginger is used for planting material. Other soil fumigation experiments conducted in areas of ginger-free crop history have shown that disease-free stock planted in such soils fumigated with Dowfume MC-33 at 450 pounds per acre averaged 10 pounds of healthy ginger rhizomes per plant as compared to 3 pounds for control plots. Studies made to control the bacterial wilt of ginger with methyl bromide fumigation have shown some promise in labora-

tory trials. Field trials, however, have shown inconclusive results.

Fumigation of soil should be a standard practice in ginger production to control *Fusarium* yellows and root-knot nematodes. Soil fumigation with a material composed of methyl bromide and chloropicrin also offers excellent weed control. Since the control of bacterial wilt with fumigation is less reliable, the grower should avoid the continuous recropping of the land. Bacterial wilt-infested fields should be placed on rotation using non-susceptible crops such as cucumbers or sweet corn. Fumigation after a year's rotation may prove more effective. Also, land that had a previous tomato family crop with bacterial wilt should not be used for ginger production without proper fumigation.

INSECT PESTS

Insect control in ginger is desirable because insects may be involved in the spread of diseases, and also because they damage the foliage and rhizomes. Au (1) listed the following species in order of importance in Hawaii.

Chinese Rose Beetle

The Chinese rose beetle, *Adoretus sinicus* (Burm.), is pale reddish-brown and has nocturnal feeding habits. The damage on the foliage is characteristic, being peppered or shot with holes, or more or less skeletonized. The eggs, which are laid in the soil, hatch in about 4 days, and the entire life cycle from egg to adult takes about 6 to 7 weeks. The larvae apparently feed on decaying plant material; pupation occurs in the soil. During the daytime, adults are usually found hiding in loose soil or among dead leaves. This species is common at low elevations.

Fullers Rose Beetle

The Fullers rose beetle, *Pantomorus godmani* (Crotch), feeds on a variety of plants including ginger. The adults are 7 to 9 millimeters long, with a short

snout, and are light brownish or grayish in color. The species is more prevalent at higher elevations, apparently requiring cooler temperatures for survival.

Grasshoppers

Ginger leaves are occasionally damaged by grasshoppers. This occurs at times when there is a high population incidence of these insects.

Scavenger Flies

Several insects breed in decaying plant tissues. These include the syrphid fly, *Eumerus marginatus* (Grims); the otitid scavenger fly, *Euxesta quadrivittata* (Macq.); and the sciarid gnat fly. The importance of these insects in ginger production remains to be determined. Field observations appear to indicate that the syrphid fly may be a threat to ginger when the crop becomes dormant. The eggs may be laid on the decaying flower stalk and the larvae may work their way down to the healthy rhizome tissues below ground. The tunnels built by the larvae in healthy rhizome tissues reduce the market value of the crop.

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**UNIVERSITY OF HAWAII
COLLEGE OF TROPICAL AGRICULTURE
HAWAII AGRICULTURAL EXPERIMENT STATION
HONOLULU, HAWAII**

THOMAS H. HAMILTON

President of the University

DALE N. GOODELL

Acting Dean of the College and
Acting Director of the Experiment Station

GEORGE STANFORD

Acting Associate Director of the Experiment Station